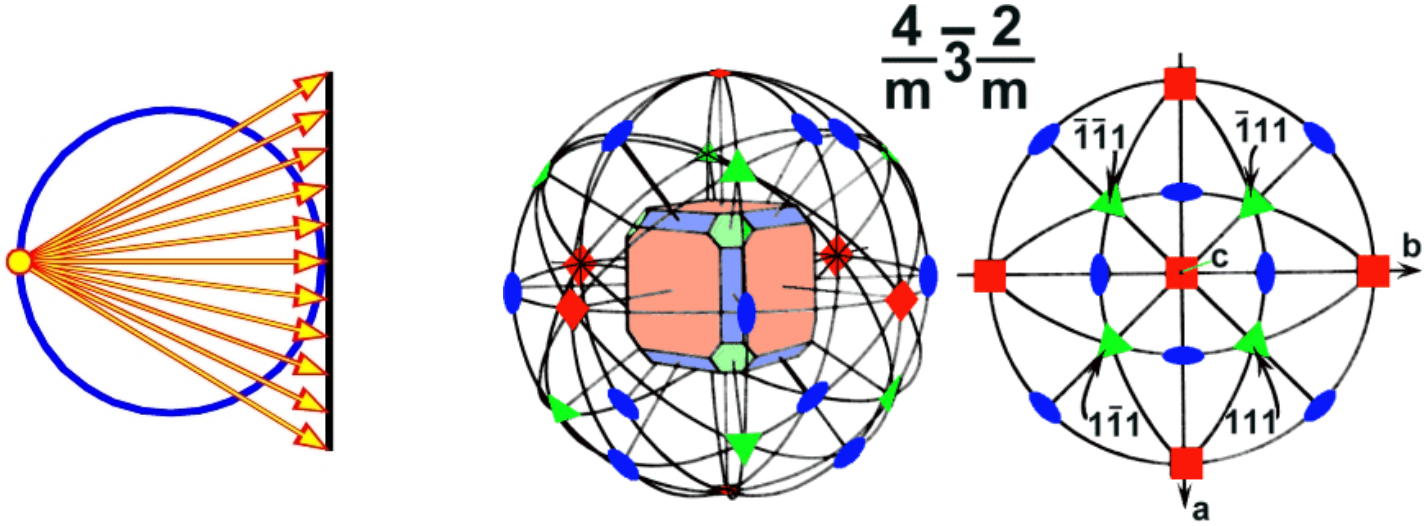
Chapter 4 Morphology and Stereographic Projection



Reading Assignment:

1. W. B-Ott, Crystallography-chapter 4
2. B. D. Cullity, Elements of X-ray Diffraction- chapter 2

http://www.cnr.colostate.edu/class_info/nr502/lg1/map_projections/light_source.html

Contents

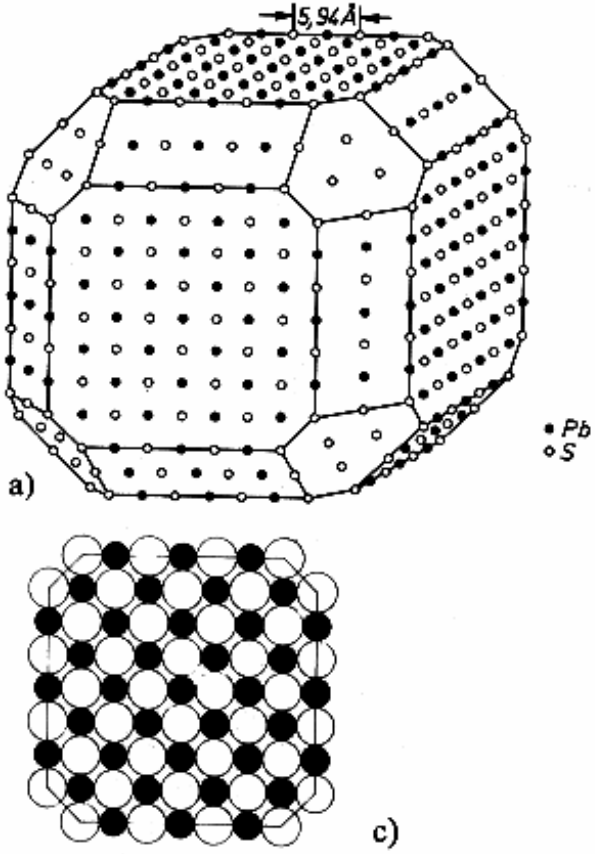
Morphology

Morphology- set of faces and edges which enclose a crystal

morphology --→ crystal structure

(external surfaces) (internal structure)

ex) PbS (galena)



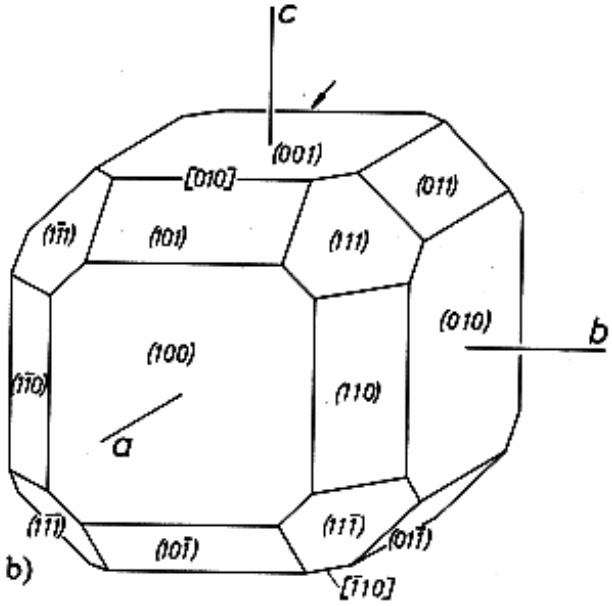
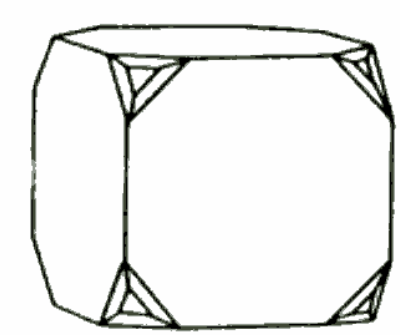


Fig. 4.1 a, b. Correspondence between crystal structure (**a**) and morphology (**b**) in galena (PbS). In **a**, the atoms are reduced to their centres of gravity (**c**) shows the atoms occupying the (100), (010) or (001) face.

PbS (galena), cubic



Morphology

- Every crystal face lies parallel to a set of lattice planes:
  parallel crystal faces correspond to the same set of planes.
- Every crystal edge is parallel to a set of lattice lines.

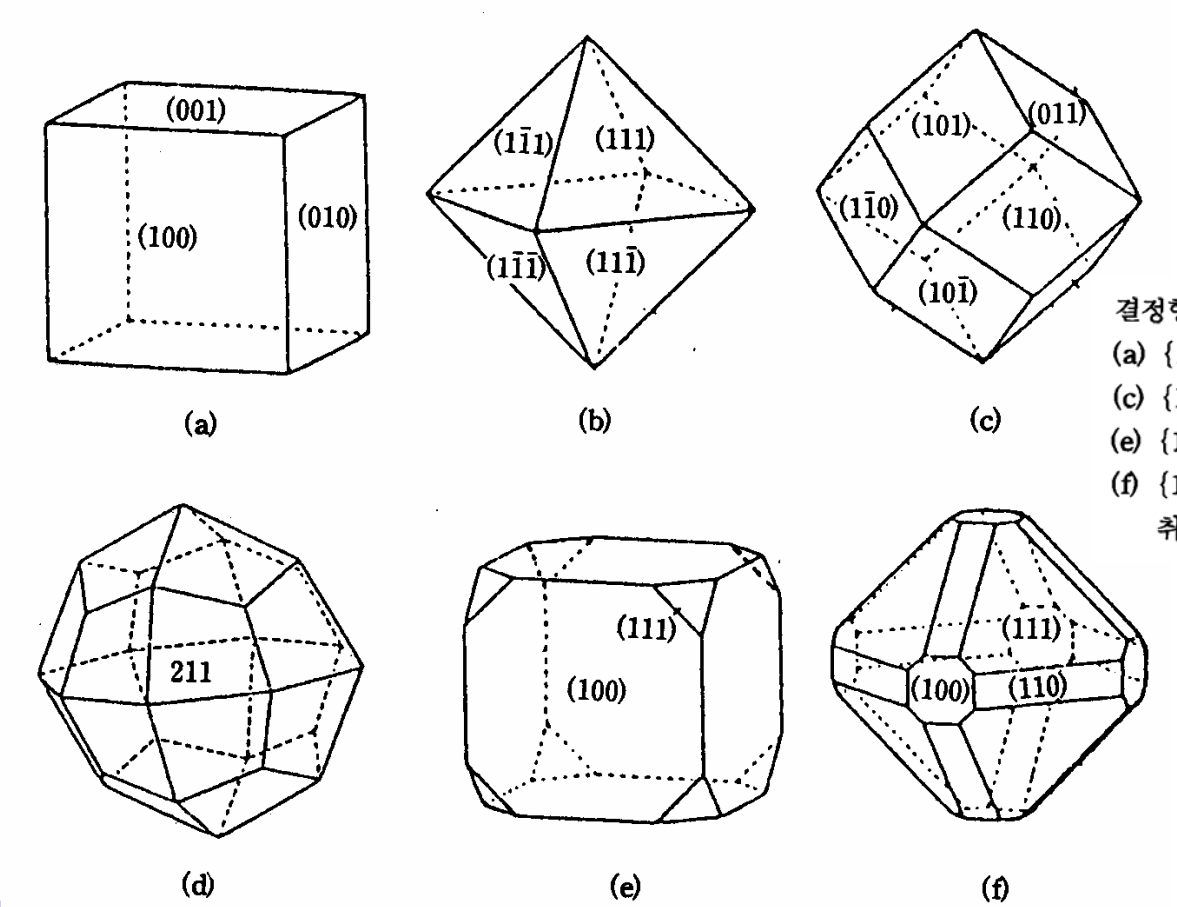
- Miller index- crystal faces
  [uvw]- crystal edge

- Morphology- no information about the size of the unit cell
  in principle ratio between one unit cell edge and another

- Lattice parameters known- angle between any pair of lattice plane can be calculated and compared with the observed angles between two crystal faces

Morphology

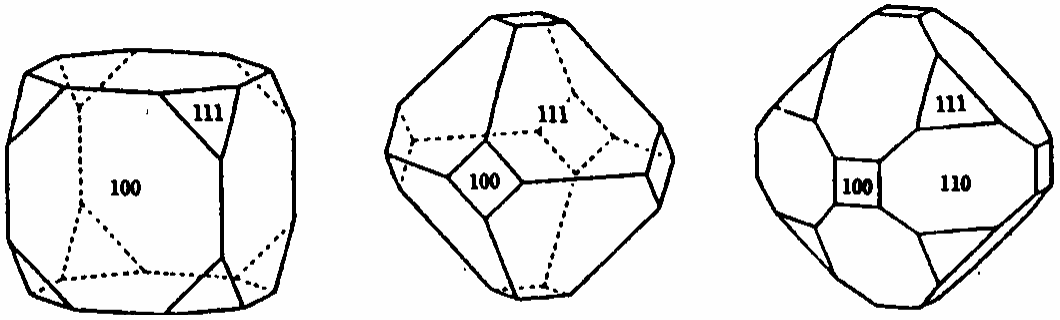
Form (결정형): 한 결정에서 외형을 이루는 동가면(equivalent faces)들의 집단, {hkl}로서 나타냄



결정형과 취형
(a) {100}, 정육면체 (b) {111}, 정팔면체
(c) {101}, 능면 십이면체 (d) {211}, 이십사면체
(e) {100}·{111}, 정육면체와 정팔면체의 취형
(f) {100}·{111}·{110}, 정육면체, 정팔면체, 정십이면체의 취형

Morphology

Habit (정벽): 결정 성장 속도의 차이에 다른 결정 외면의 상대적인 발달에 따라 어떤 특정한 결정형이 두드러지게 잘 나타나는 성질



(a) 정육면체 정벽 (b) 정팔면체 정벽 (c) 능면 십이면체 정벽

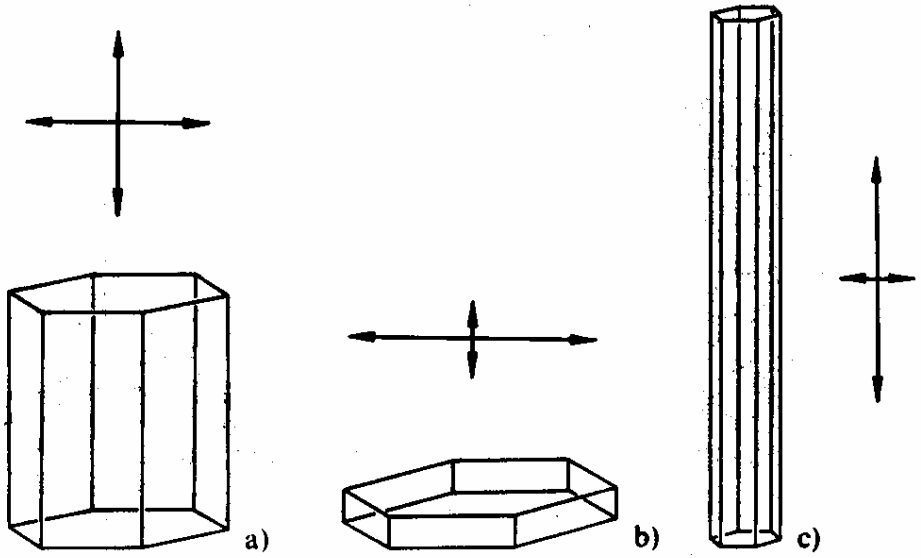


Fig. 4.2a–c. The three basic habits: **a** equant, **b** planar or tabular, **c** prismatic or acicular with the relative rates of growth in different directions shown by *arrows*

Morphology

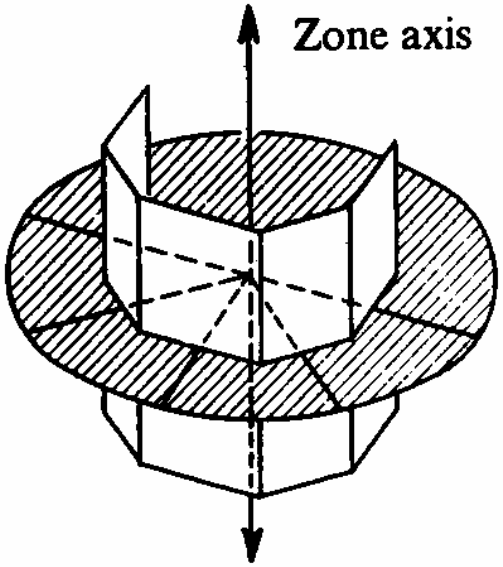
Zone: a set of crystal faces whose lines of intersections are parallel

Tautozonal: faces belonging to the same zone

Zone axis: a direction parallel to the lines of intersection

* normals to all the faces in a zone are coplanar

zone axis is normal to this plane



ex) galena crystal (PbS)

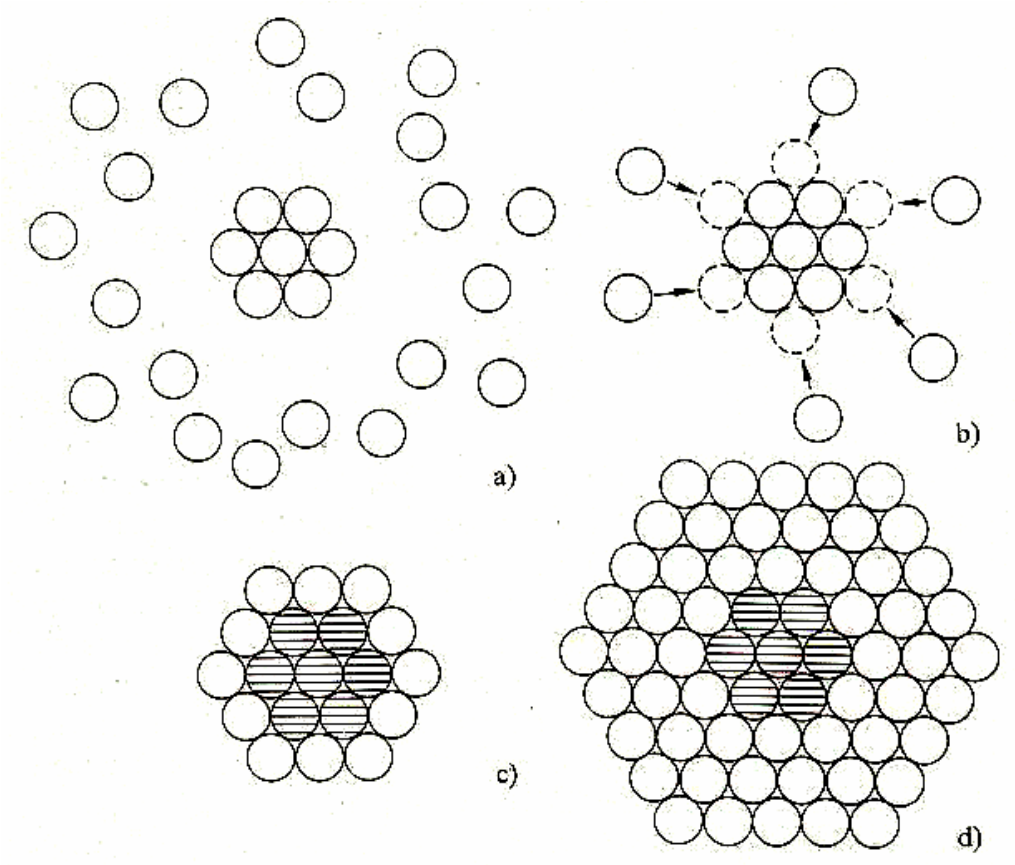
$$[(101)/(10\bar{1})] = [010]$$

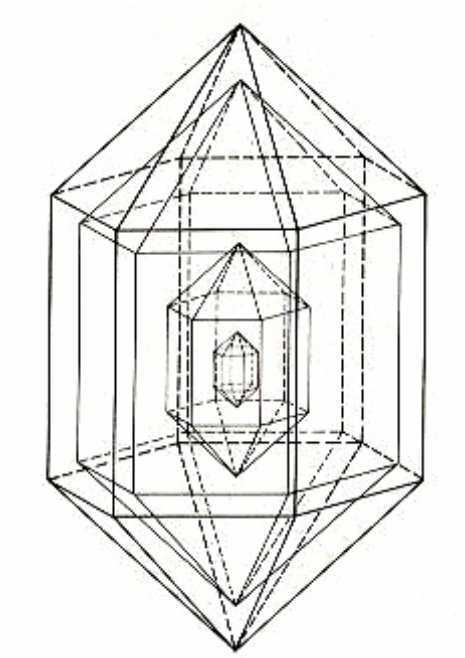
*If (h_1,k_1,l_1), (h_2,k_2,l_2), (h_3,k_3,l_3) are tautozonal if and only if

$$\begin{vmatrix} h_1 & k_1 & l_1 \\ h_2 & k_2 & l_2 \\ h_3 & k_3 & l_3 \end{vmatrix} = 0$$

Crystal Growth

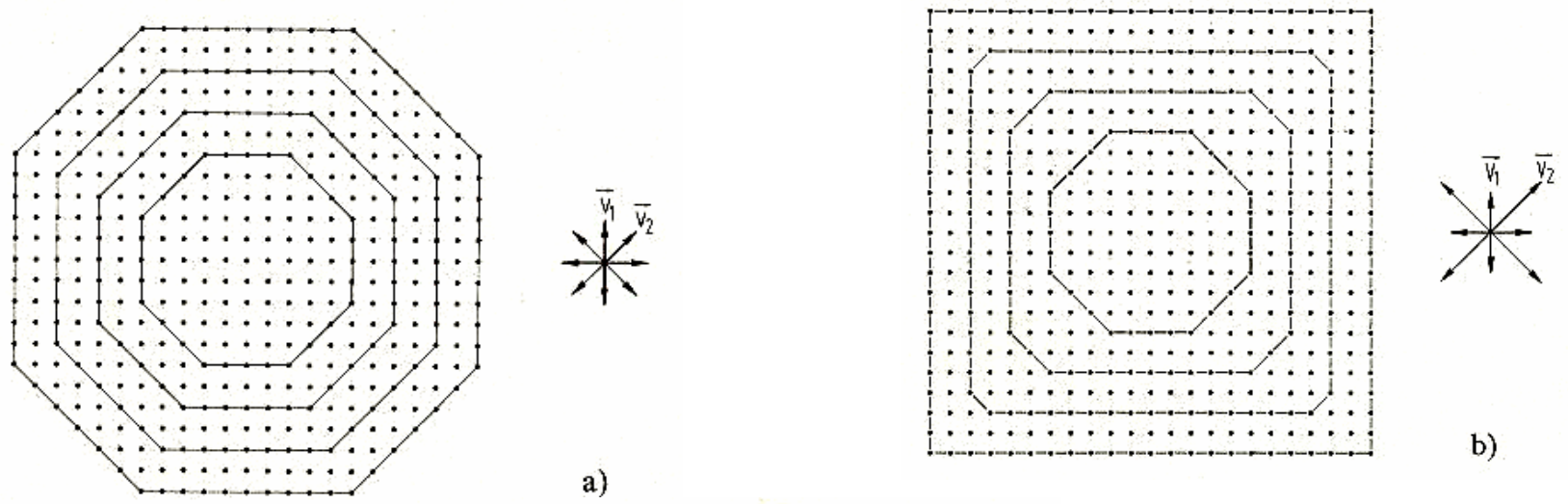
- **Nucleation and growth**

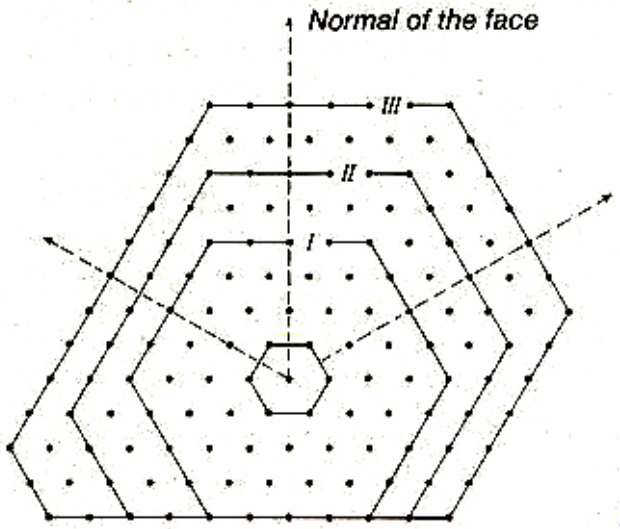




Crystal Growth

- difference in growth rate → crystal habit
- law of constancy of the angle

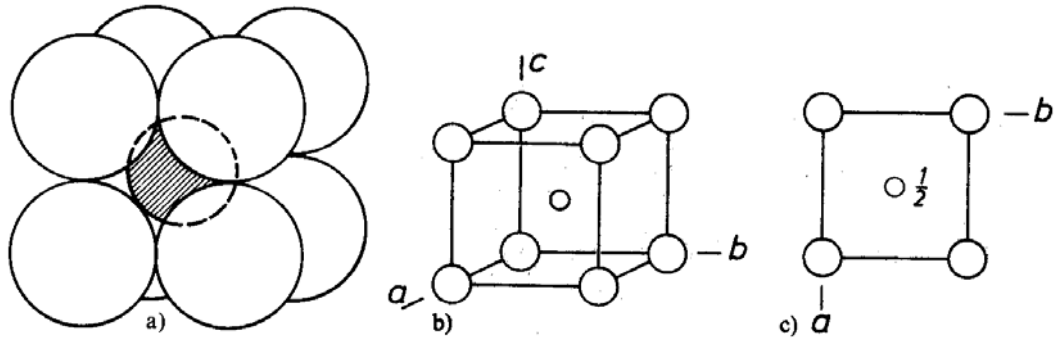




Contents

Projections

- three dimensional objects → flat surfaces
- parallel projection



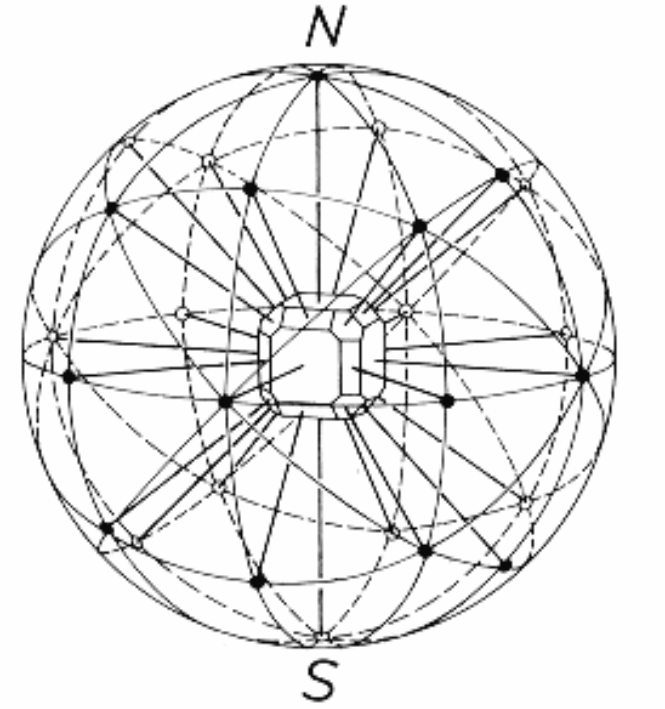
- stereographic- angular relationship between lattice planes and directions

  gnomonic

  orthographic

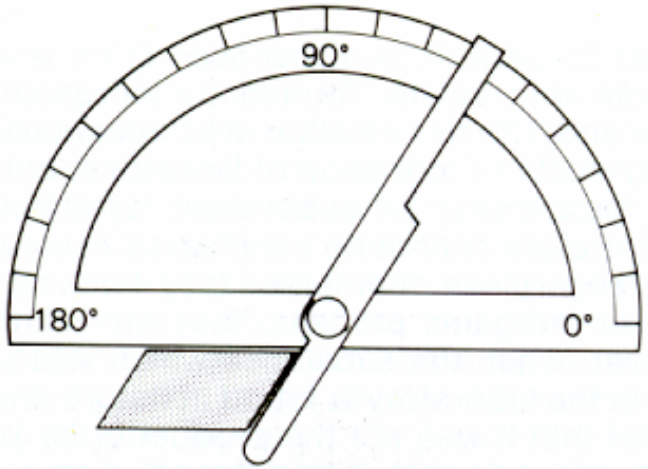
Stereographic Projections

- place a crystal at the center of the sphere
- draw normal to each faces from the center of the sphere
- cut the surface of the sphere in the indicated points (**pole**)
- **great circles**- circles whose radius is that of the sphere
- those faces whose pole lie on a single great circle- a single zone
- zone axis- perpendicular to the plane of the great circle

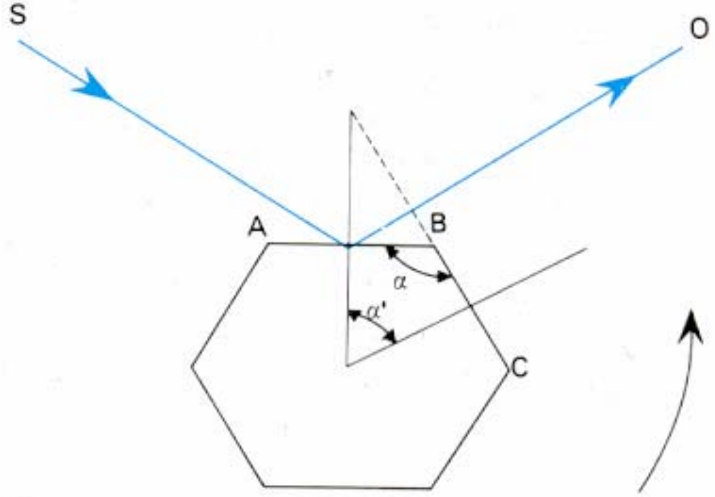


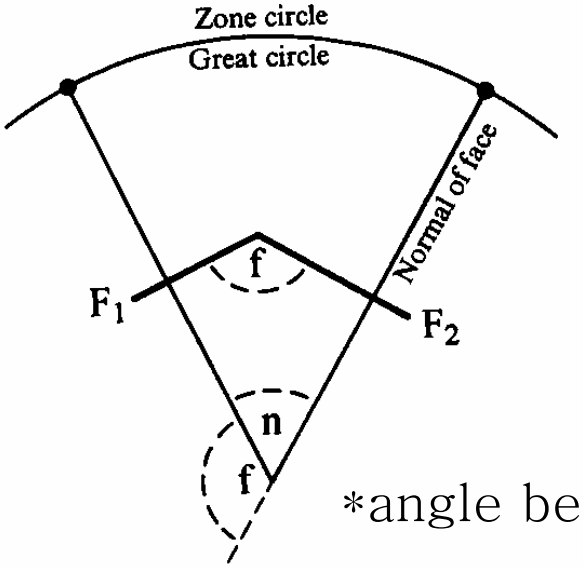
Stereographic Projections

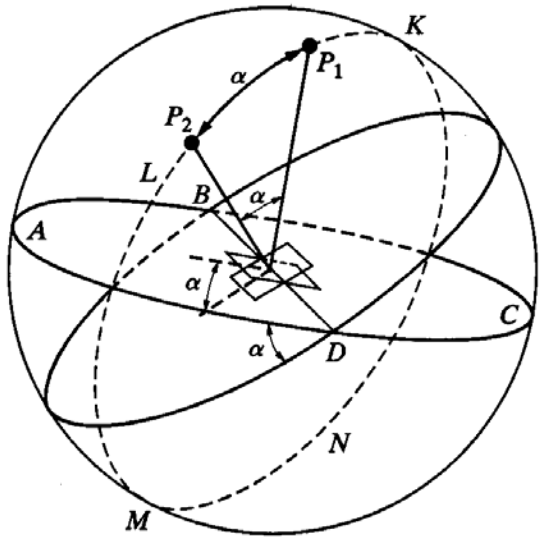
Contact goniometer



Reflecting goniometer





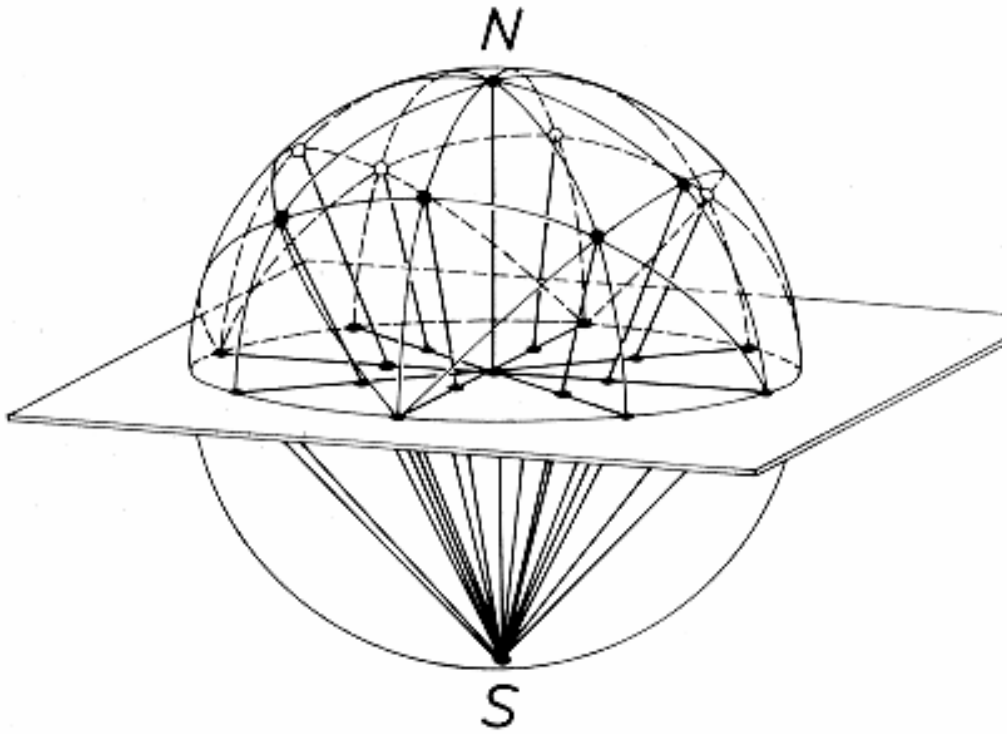


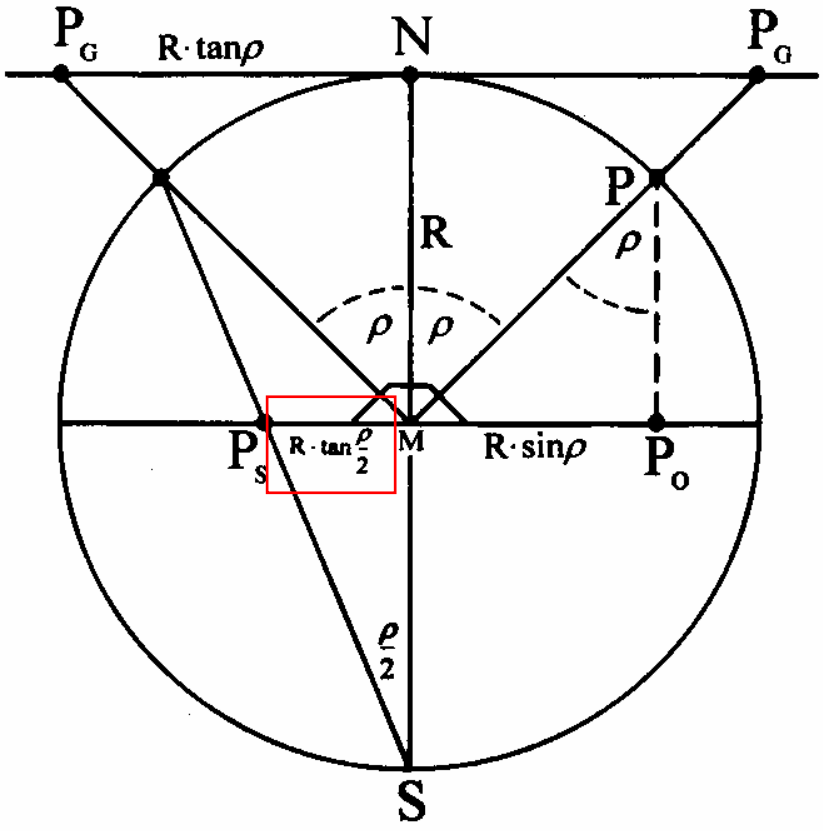
*angle between normals n

n=180-dihedral angle f

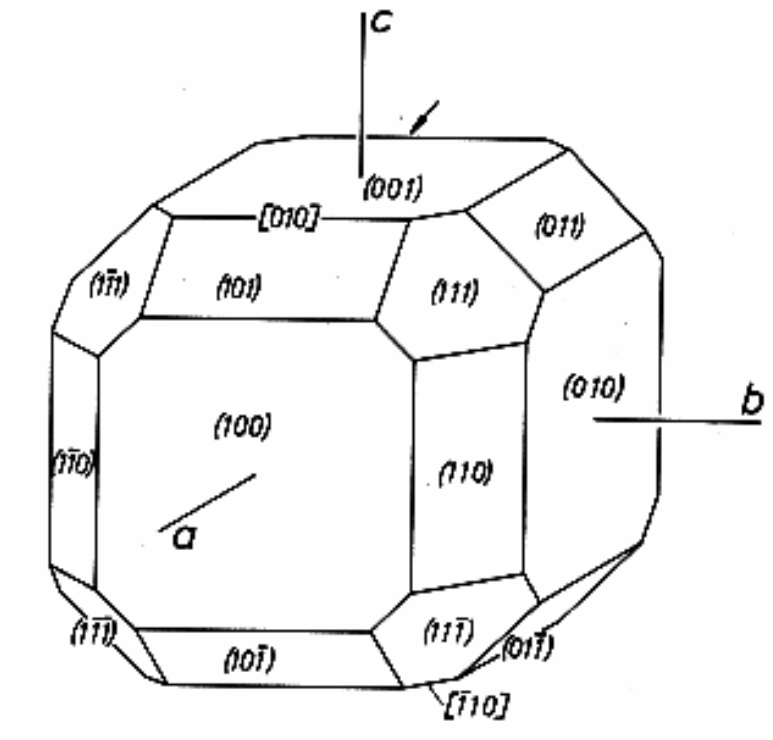
Stereographic Projections

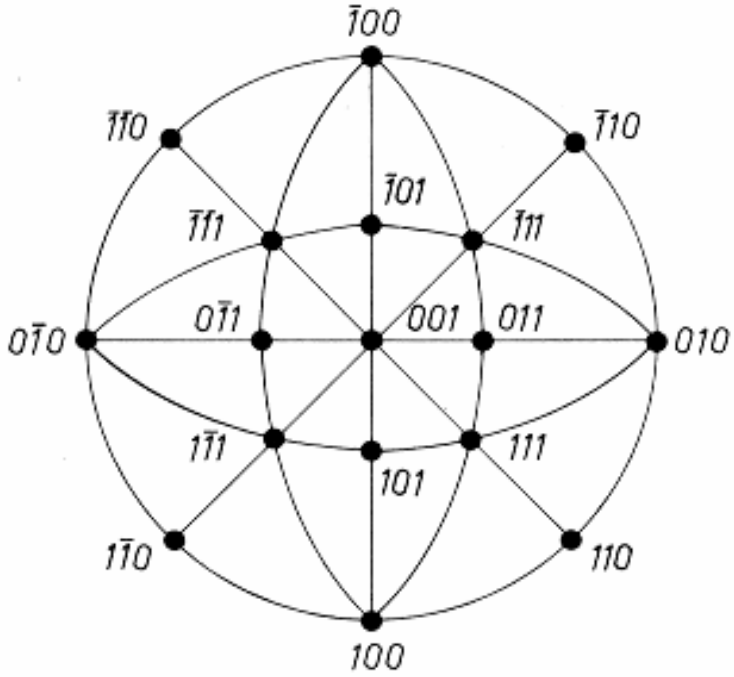
- project a line from each of the poles in the northern sphere to the south pole
- mark its intersection with the plane of the equator with a point •



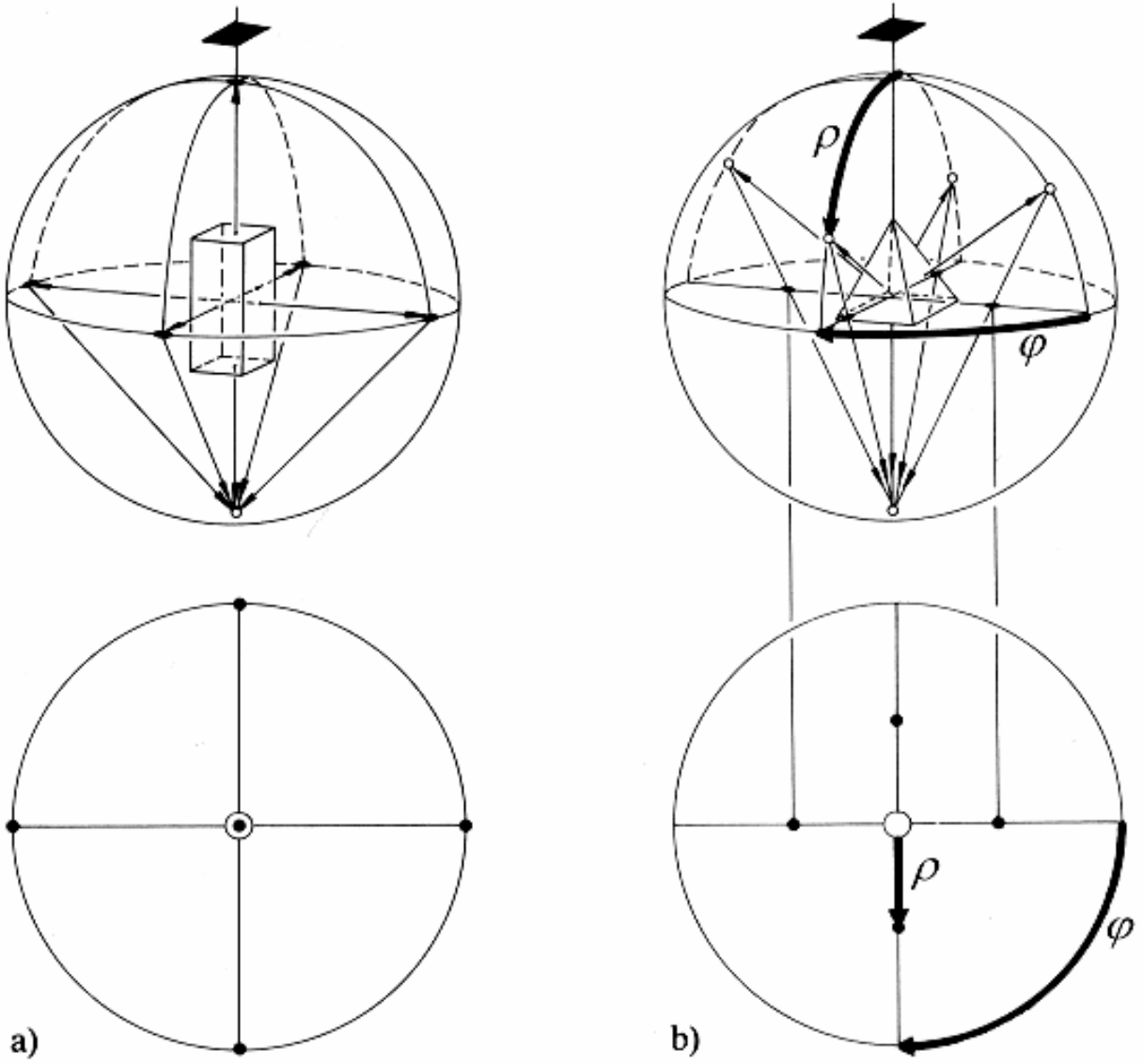


Stereographic Projections





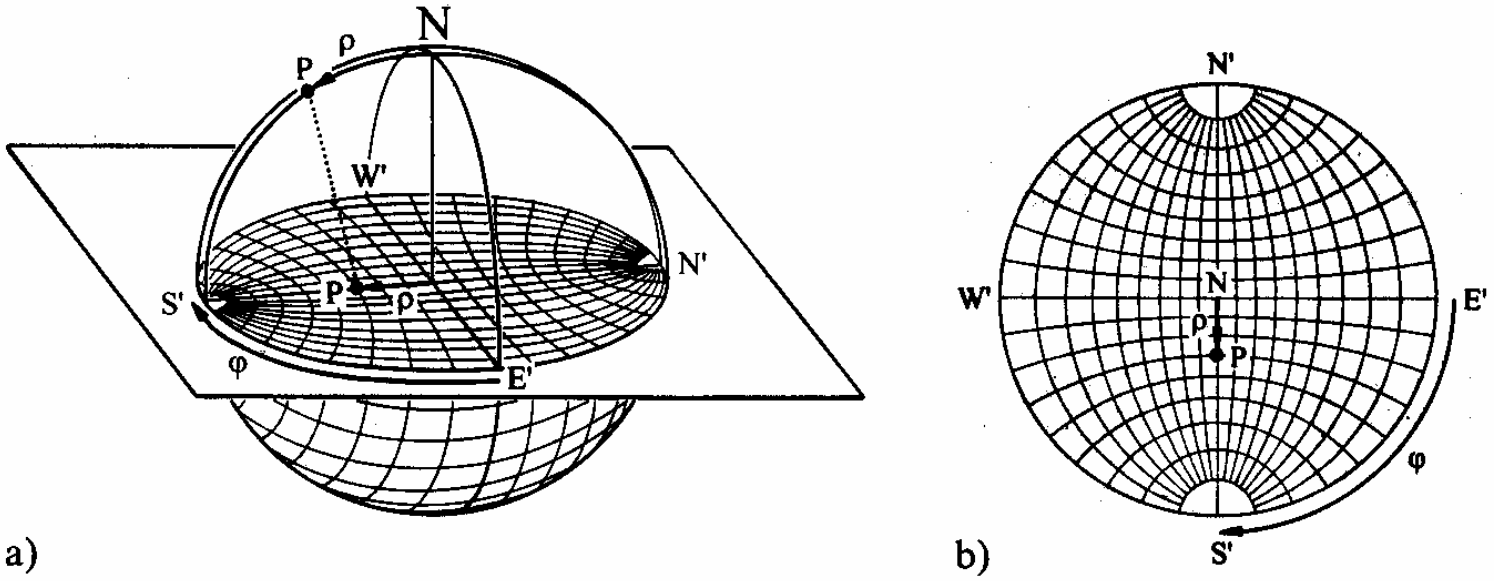
Stereographic Projections



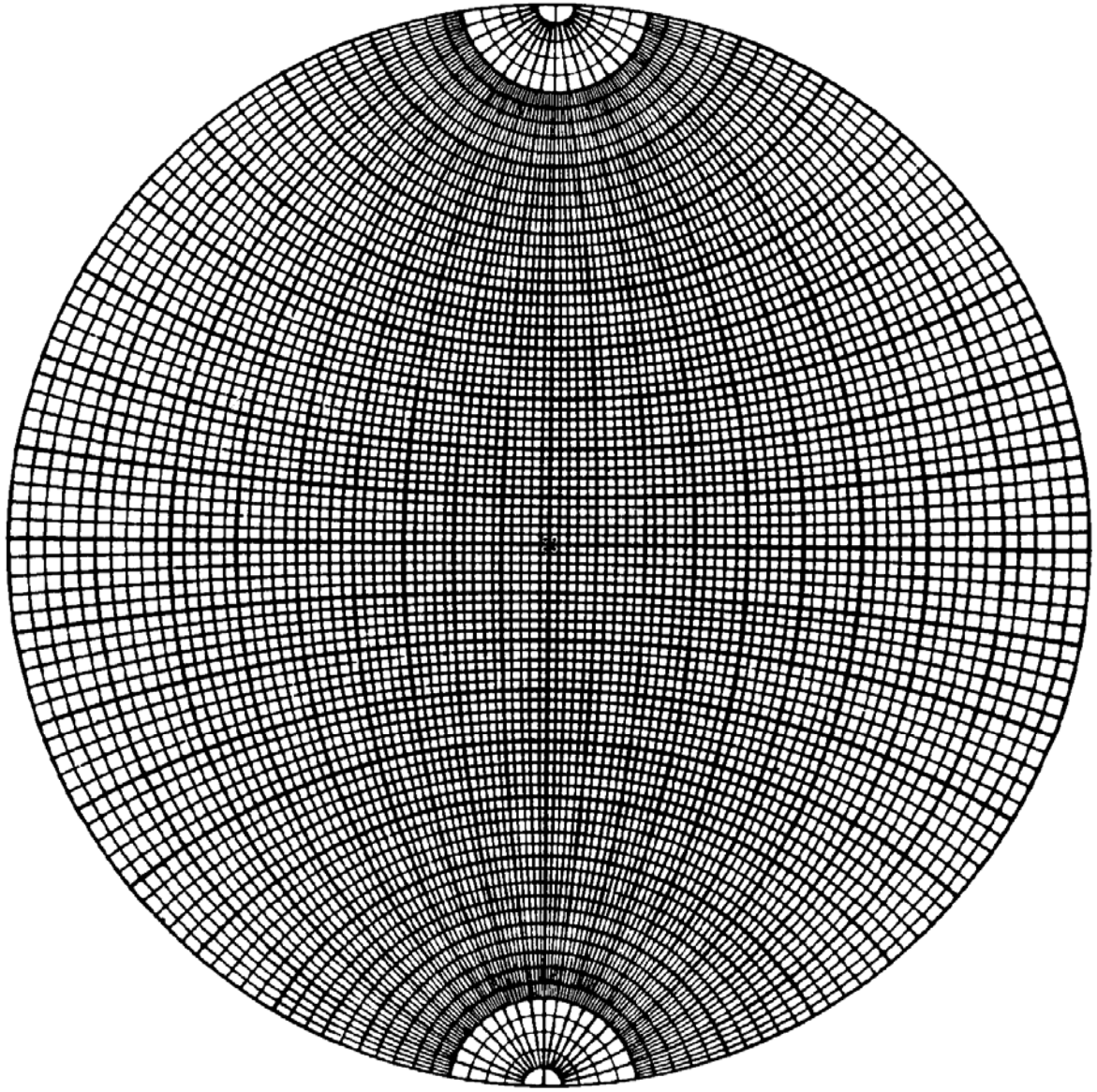
Stereographic Projections

Wulff net: - a device to enable the measured crystal angles to be plotted readily as a stereographic projection.

- stereographic projection of the grid of a conventional globe oriented so that the N'-S' direction lies in the plane of projection $(NS \perp N'S')$
- equator, all meridians- great circle
- parallels except equator- small circle
- azimuthal angle φ and pole distance ρ

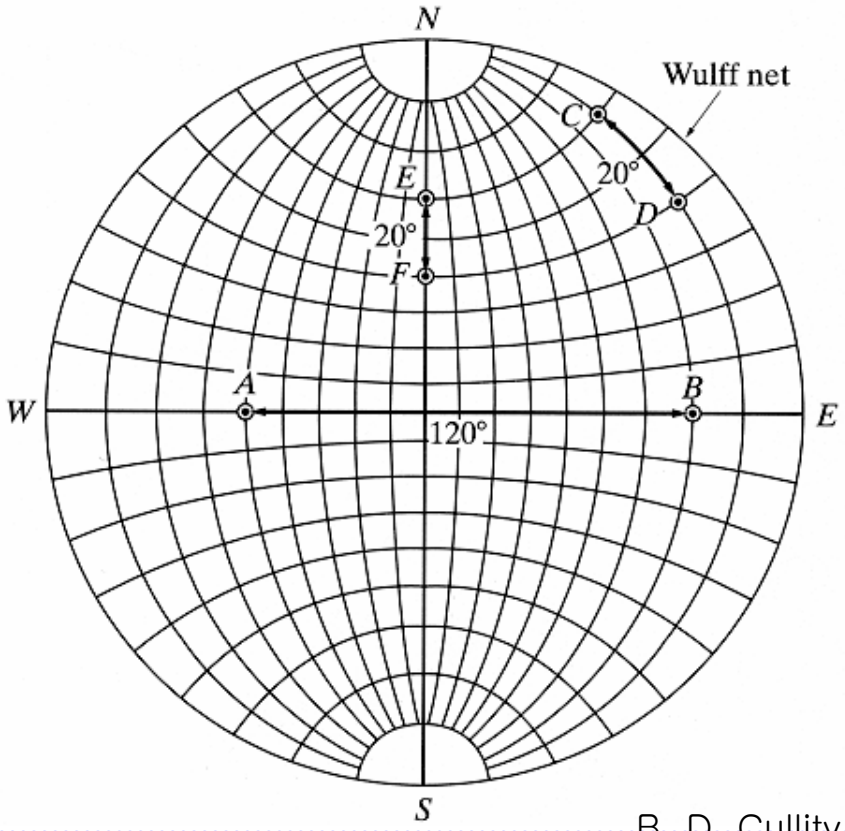


Stereographic Projections



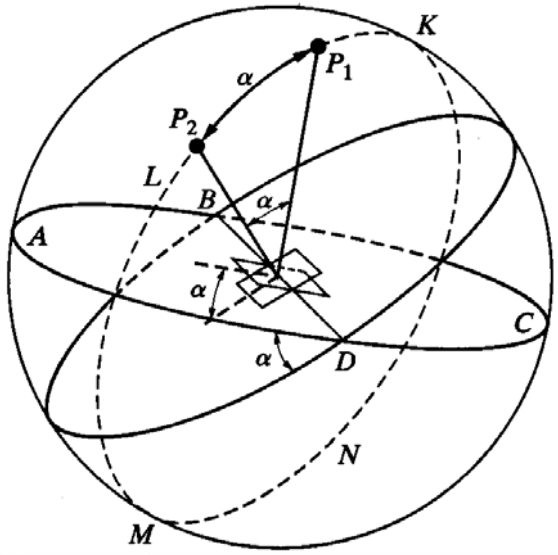
Stereographic Projections

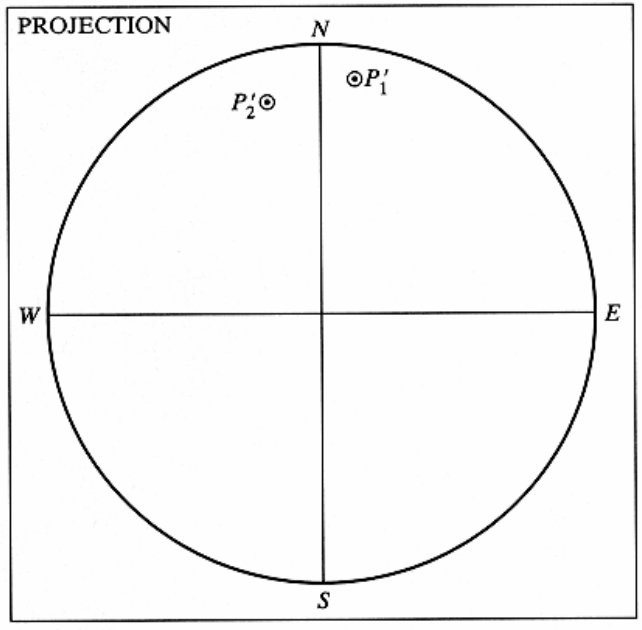
- "Only arcs of great circles are used when angles are plotted on or estimated from a stereographic projections"
- stereographic projection superimposed on Wulff net for measurement of angle between poles
- direct measurement along great circle

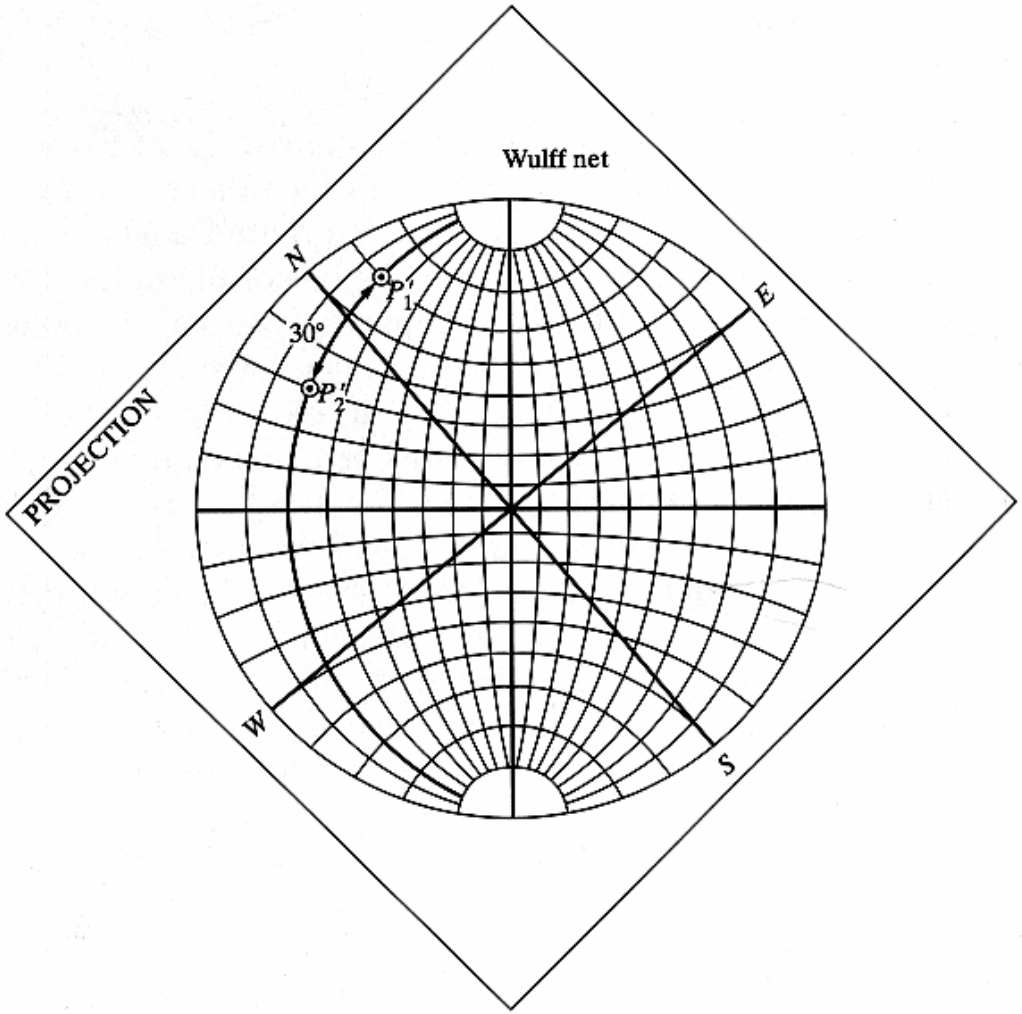


Stereographic Projections

- rotate relative to the wulff net and lie on a great circle





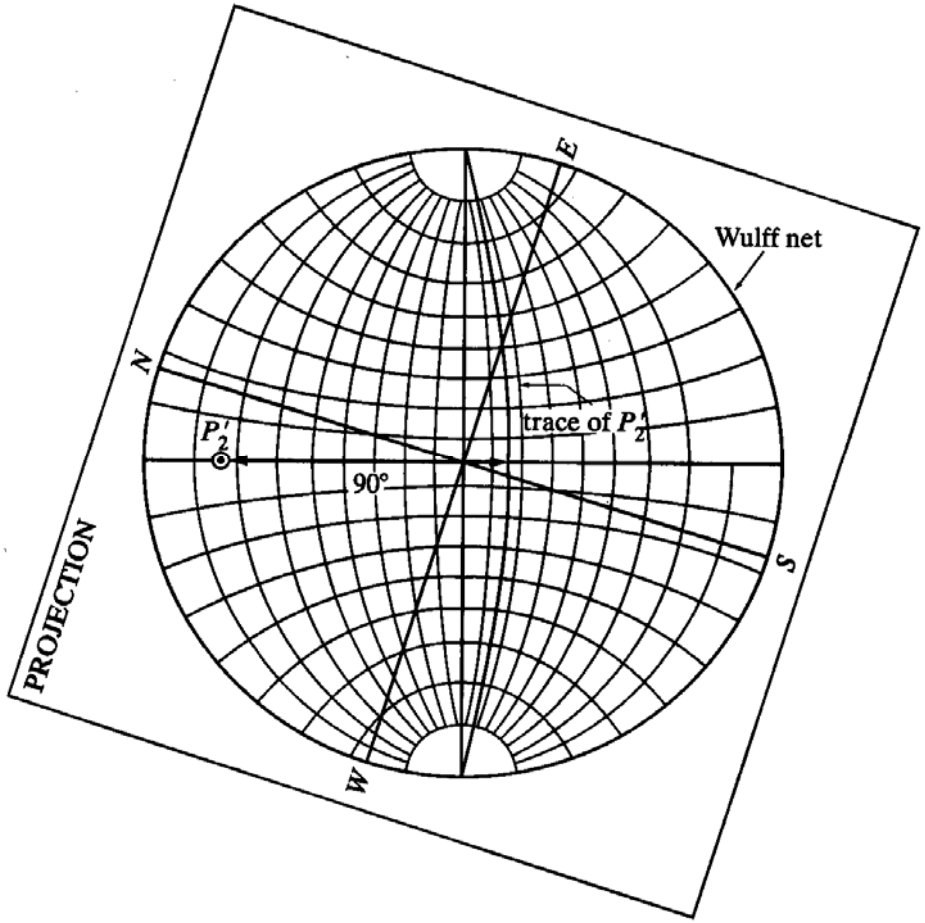


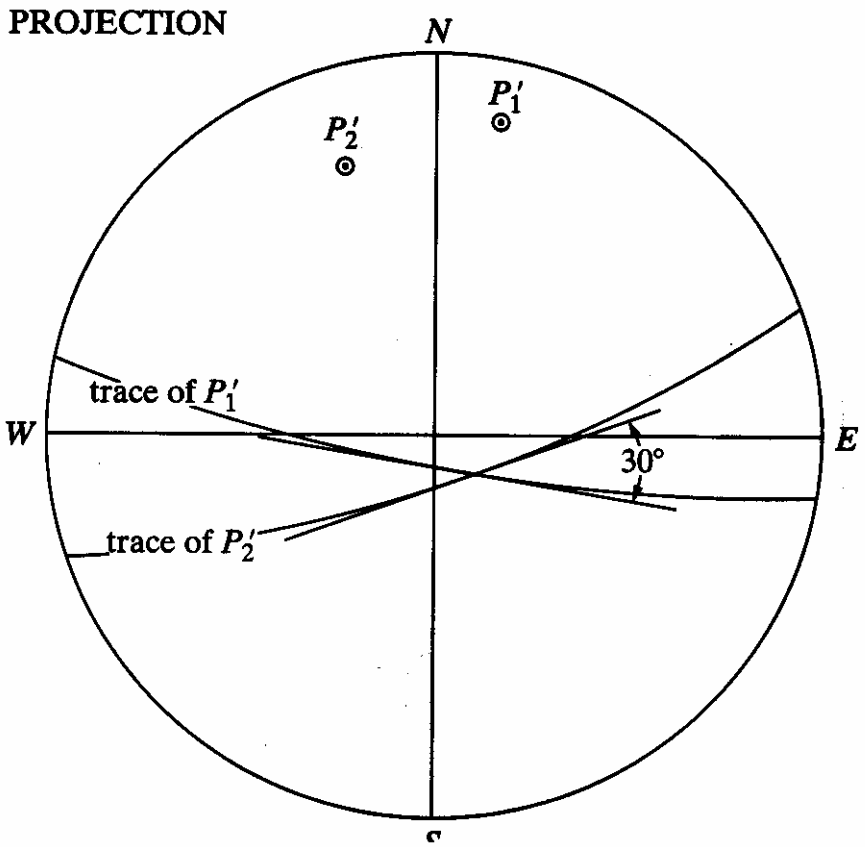
B. D. Cullity, Elements of X-ray Diffraction

Stereographic Projections

- to find the trace of a pole

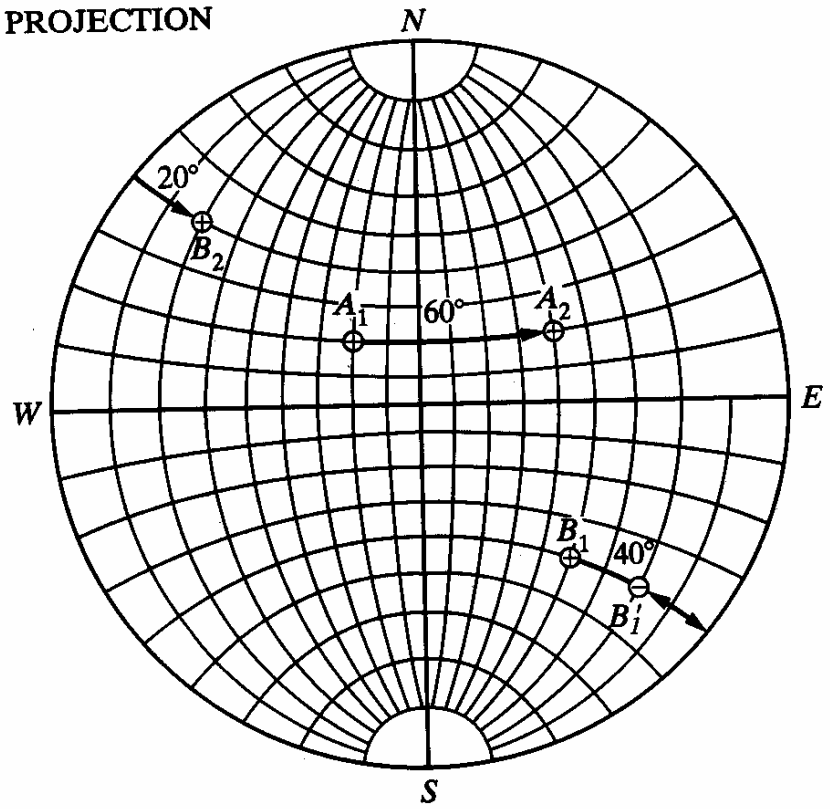
- angle between two poles vs. angle of intersection of the corresponding traces





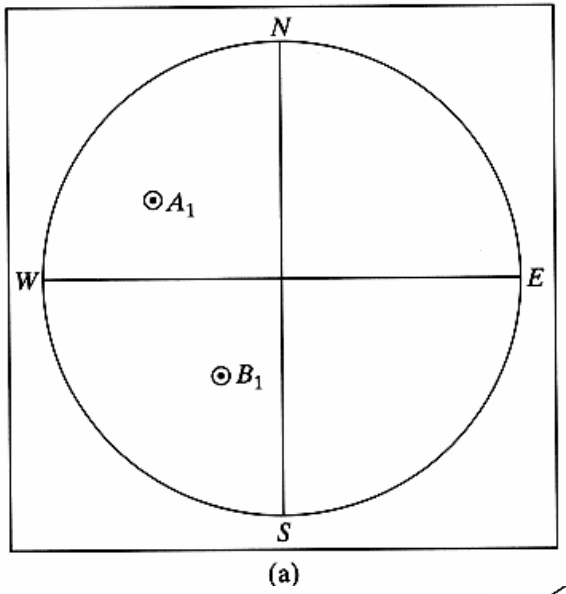
Stereographic Projections

- rotation of poles about NS axis of projection

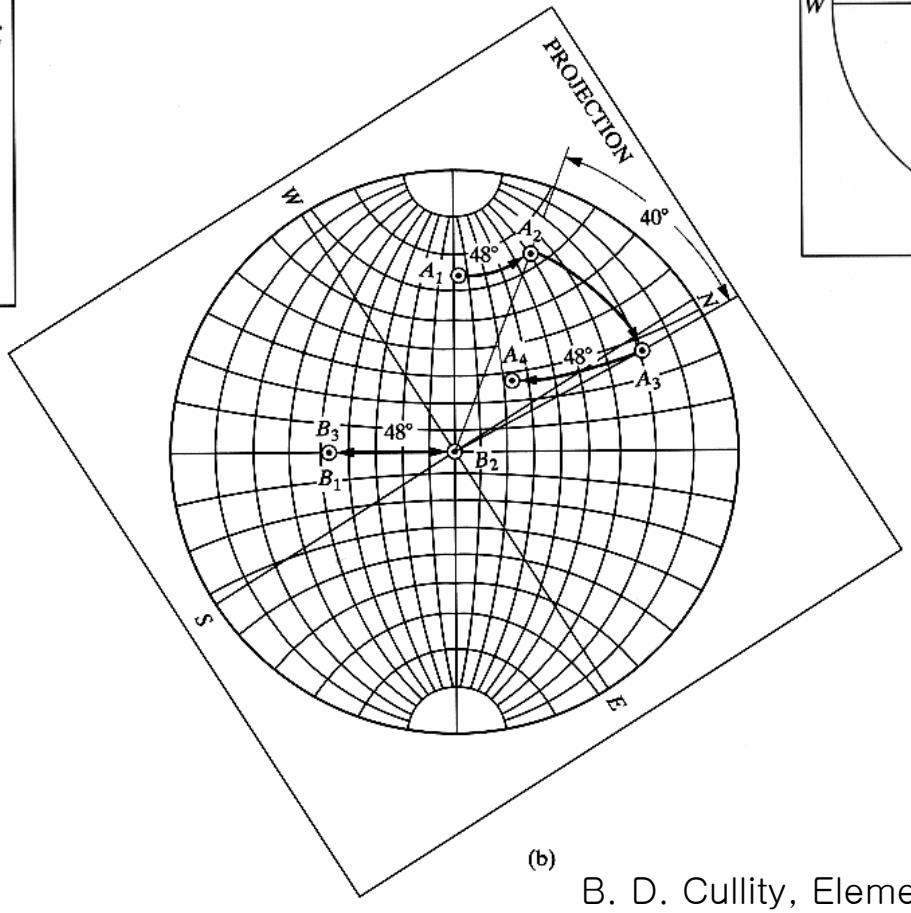


Stereographic Projections

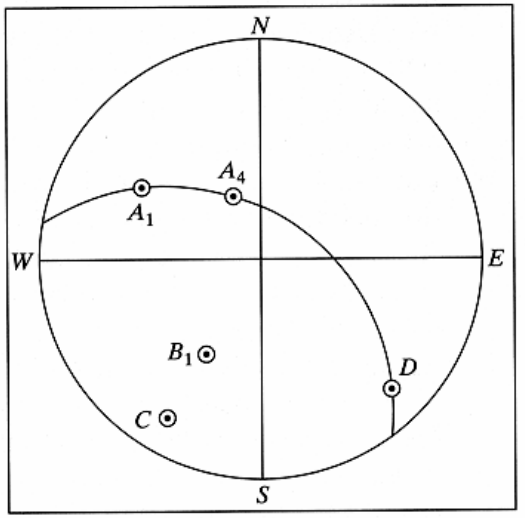
- rotation of a pole about an inclined axis
  (A_1 rotate about B_1 by 40° in a clockwise direction)



(a)



(b)



(c)

Stereographic Projections

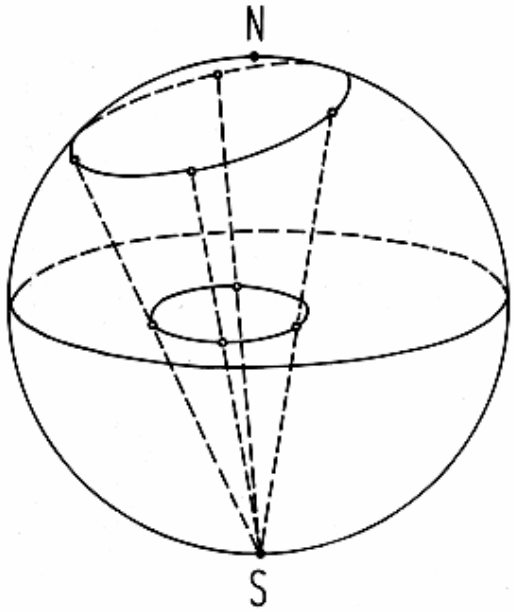


Fig. 4.17. A circle on the surface of a sphere remains a circle in its stereographic projection on the equatorial plane

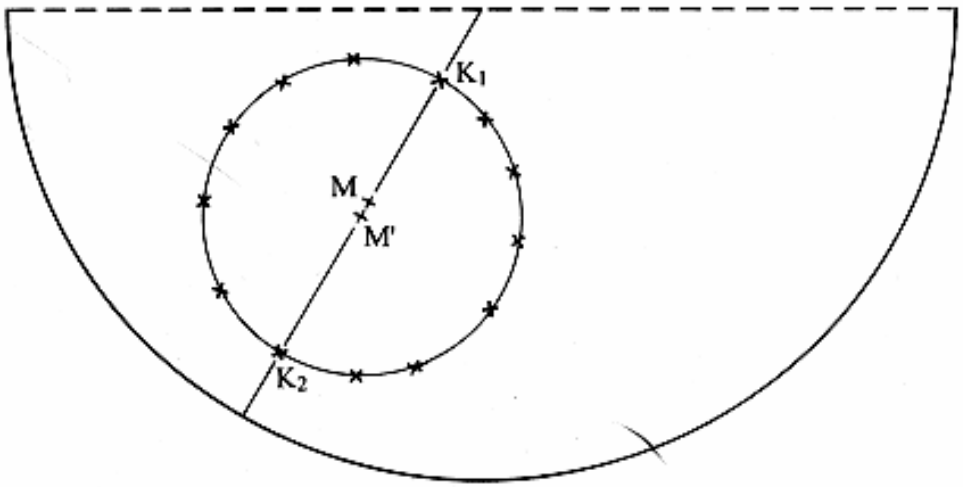
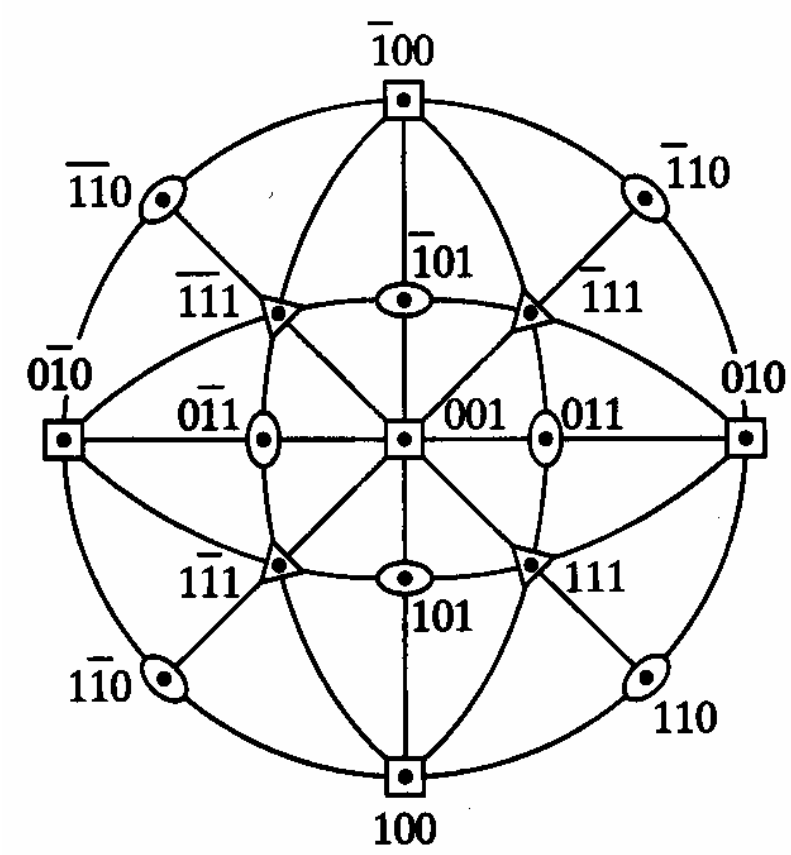


Fig. 4.18. Detail of the equatorial plane of a stereographic projection. Points 30° from a pole M are shown. These poles lie on the circumference of a circle, whose centre M′ may be found by bisecting the diameter K_1K_2

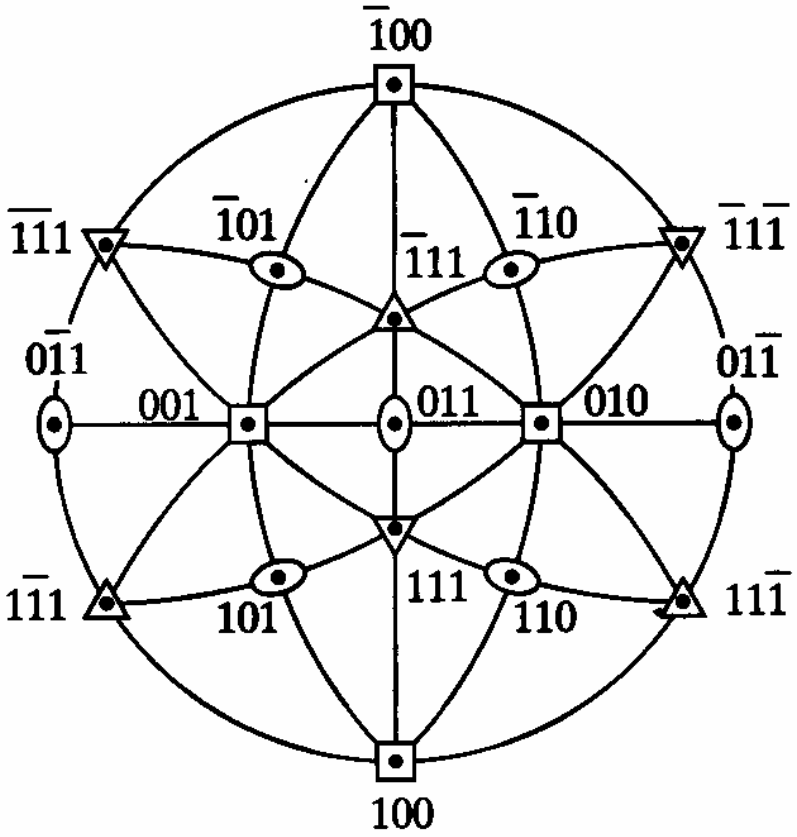
Stereographic Projections

- standard cubic stereographic projections

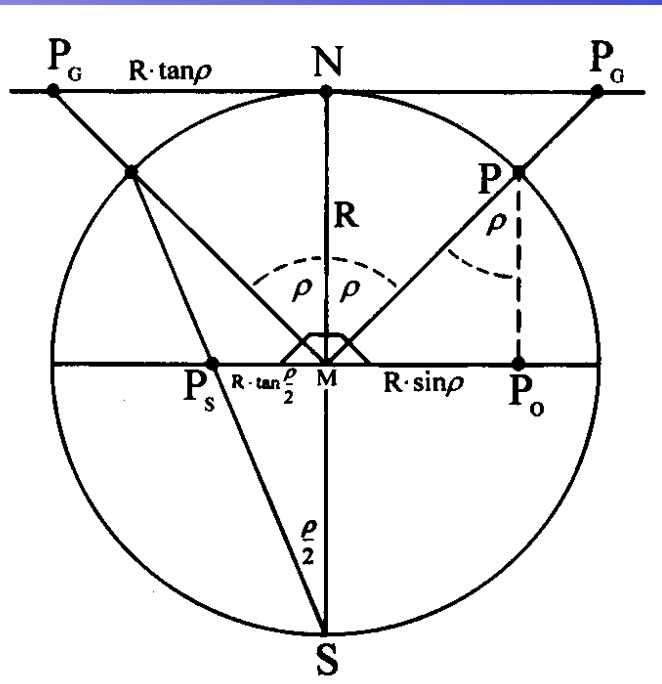
(001)



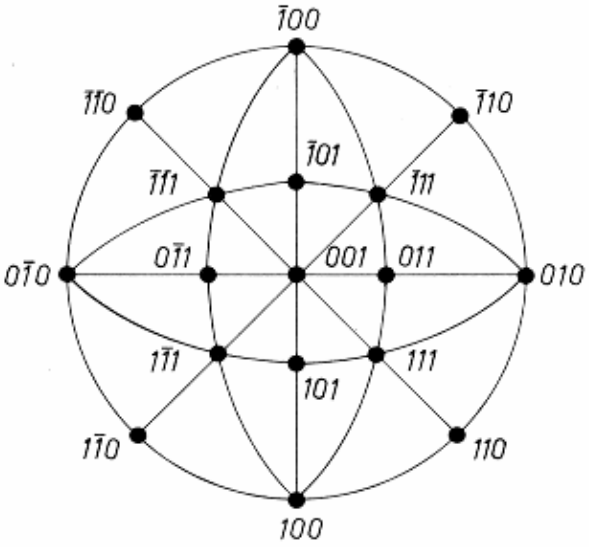
(011)



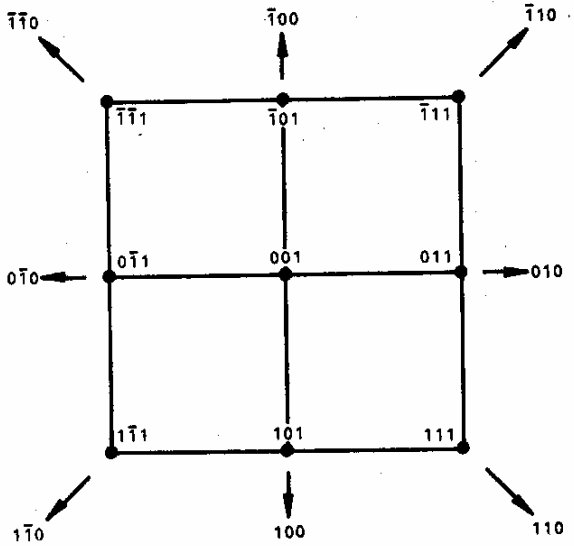
Projections



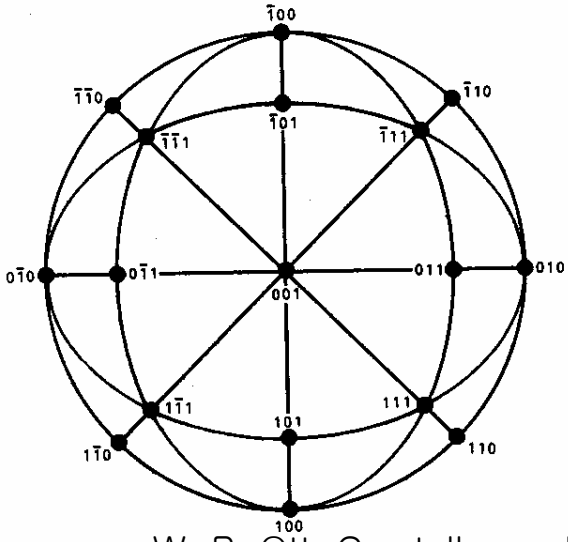
- stereographic



- gnomonic



- orthographic



W. B-Ott, Crystallography